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The Perturbations of Halley's Comet in the Past. Third Paper. The Period from 1066 *to* 1301. By P. H. Cowell and A. C. D. Crommelin.

We have again to acknowledge the continued kind assistance of Dr. Smart and Messrs. F. R. Cripps and Thos. Wright, who have done a large portion of the mechanical quadratures for this period.

We commence by indicating some small corrections to the values of n at various returns which we gave in the first paper; these arise chiefly from the introduction of the definite integral for Venus and the Earth from the table on p. 386. The corrected values are, 1531 46″·339, 1456 46″·021, 1378 45″·622, 1301 44″·862.

We next give the full table of perturbations for the revolution 1222 to 1301. It will be seen that the effect of the change of n and the action of the smaller planets has an appreciable influence on our former result.

Revolution 1222 *to* 1301.

Planet.	Limits of u.	$\int dn$.	$\int d\varpi$.	$\int d\zeta$.
	° °	″	″	″
Venus	0– 30	+ ·0069	...	+ 198
,,	30–330	− ·0013	...	− 50
,,	330–360	− ·0070	...	0
Earth	0– 30	+ ·0045	...	+ 128
,,	30–330	− ·0049	...	+ 31
,,	330–360	+ ·0089	...	0
Jupiter	0– 90	− ·2444	− 186	− 7040
,,	90–270	− ·0175	− 167	+ 7894
,,	270–360	+ ·5694	− 186	− 343
Saturn	0– 90	− ·0590	+ 24	− 1555
,,	90–270	+ ·0569	− 37	+ 1437
,,	270–360	− ·2366	+ 16	+ 35
Uranus	0–360	− ·0147	− 1	− 34
Neptune	0–360	+ ·0010	− 6	+ 219
	Sums	+ ·0622	− 543	+ 920

Hence n at 1222 = 44″·862 − ″·062 = 44″·800.

$$\text{Theoretical period in days} = \frac{1296000 - 920}{44{\cdot}800} = 28908^{d}{\cdot}0.$$

Calculated date of perihelion passage 1222 August 30·7 = Julian day 2167635·7. This is 17 days later than our former provisional calculated value, and 9 days later than the day we adopted for the perihelion passage. As the computations for the revolution 1145 – 1222 indicated a still later date for the perihelion passage in 1222, we have reconsidered our interpretation of the observa-

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tions of that year and decided to abandon our conjecture that the date of passage of Yew She Te should be mid-August instead of mid-September, though we still think it probable that the comet was seen in August by some of the Chinese observers, since we cannot otherwise explain the statement that it was seen in China for two months ending October 8.

We now put the perihelion passage on 1222 September 10, with a probable error of several days; the conditions were thus practically the same as at the return of 1682, when the comet was circumpolar in Ursa Major in mid-August; we suppose now that the phrase "La Lune joignit la comète" refers not to the date in mid-August when the comet was first seen, but to September 13, when the two bodies were really close together.

A further advantage of the new date is that it puts the comet considerably nearer Antares on October 8 than the former value did; this accords with the Chinese account. We pass now to the preceding revolution; as before, we provisionally took Hind's value of the perihelion passage, viz. 1145 April 19, for the purpose of calculating the perturbations, and deduce the following quantities:—

Revolution 1145 *to* 1222.

Planet.	Limits of *u*.	$\int dn$.	$\int d\varpi$.	$\int d\zeta$.
	° °	″	″	″
Venus	0– 30	+·0091	...	+ 275
,,	30–330	+·0063	...	+ 157
,,	330–360	−·0021	...	0
Earth	0– 30	−·0109	...	− 290
,,	30–330	−·0006	...	+ 209
,,	330–360	+·0064	...	0
Jupiter	0– 90	+·8690	−181	+24797
,,	90–270	−·0506	−277	− 3501
,,	270–360	−·9932	+256	+ 153
Saturn	0– 90	+·1276	− 89	+ 3661
,,	90–270	−·0411	+ 56	+ 921
,,	270–360	+·0158	− 72	− 38
Uranus	0–360	−·0118	...	− 42
Neptune	0–360	−·0015	...	− 46
	Sums	−·0776	−307	+26256

Now allowing for the fact that the adopted perihelion passage in 1222 is 11 days later than that previously calculated, the adjusted value of *u* at 1222 $= 44''\cdot820$; hence that at 1145 is $44''\cdot820 + ''\cdot078 = 44''\cdot898$. And calculated period in days $= \dfrac{1296000 - 26256}{44\cdot898} =$

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28280·6 days. Now 1222 September 10 = Julian day 2167646. Hence the calculated date of the preceding passage = 2139365·4 = 1145 April 6·4. This is 12·6 days earlier than Hind's date, a quantity sufficiently small to make it certain that Hind's identification of the comet of 1145 with Halley's is correct. Hind's date may be a few days in error, the observations being too vague to fix it with precision. We take the elements as follows (on the old system), ϖ being computed from the perturbations and ☊ from our assumed uniform motion,

$$\begin{aligned} T &= 1145 \text{ April } 19. \\ \left.\begin{aligned} \varpi &= 294^\circ\!.5 \\ ☊ &= 39.9 \\ i &= 16.5 \end{aligned}\right\} & \text{ Equinox of 1145.} \\ q &= 0.6 \end{aligned}$$

Motion retrograde.

We now pass to the preceding revolution, Hind's date of perihelion passage in 1066 being provisionally adopted for the purpose of computing the perturbations.

Revolution 1066 *to* 1145.

Planet.	**Limits of *u*.**	$\int dn$.	$\int d\varpi$.	$\int d\zeta$.
	° °	″	″	″
Venus	0– 30	+·0013	...	+ 39
,,	30–330	–·0087	...	– 57
,,	330–360	–·0093	...	0
Earth	0– 30	–·0167	...	– 479
,,	30–330	+·0079	...	+ 190
,,	330–360	–·0096	...	0
Jupiter	0– 90	–·0614	+250	–1845
,,	90–270	+·0710	–204	+7655
,,	270–360	+·2486	–401	– 68
Saturn	0– 90	+·0264	– 8	+ 773
,,	90–270	–·0222	–102	– 604
,,	270–360	+·0096	+ 58	– 2
Uranus	0–360	–·0050	...	0
	Sums	+·2319	–407	+5602

Allowing for the fact that the adopted perihelion passage in 1145 is 12 days later than that previously calculated, the adjusted value of *n* at 1145 is 44″·918. Hence that at 1066 is 44″·918 – ″·232 = 44″·686. And calculated period in days $= \dfrac{1296000 - 5602}{44\cdot686} =$

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28877·0 days. Now 1145 April 19 = Julian day 2139378. Hence the calculated date of the preceding passage is 2110501 = 1066 March 28. This is only 4 days earlier than Hind's date, so that his identification of the famous comet that preceded the Norman Conquest with Halley's comet is fully established. His elements, however, require to be modified, and the following elements, in which ϖ is given its calculated value, and Ω its value by our formula, satisfy the observations with sufficient accuracy, considering the vagueness of the descriptions.

$$T = 1066 \text{ March } 27.$$
$$\left.\begin{array}{rcl} \varpi &=& 293^\circ{\cdot}3 \\ \Omega &=& 38{\cdot}6 \\ i &=& 16{\cdot}5 \end{array}\right\} \text{Equinox of 1066.}$$
$$q = 0{\cdot}6'$$

According to these elements, the comet would be a morning star, in longitude 343°, latitude +9°, near θ Piscium on April 2, would pass to the evening side of the Sun on April 24, when it would be in Gemini and extremely near the Earth; finally, on May 15 it would be in longitude 148°, latitude −10°, and would then be nearly stationary, its place on May 30 being longitude 149°, latitude −8°. These places accord well with the description from Pingré: "Au jour Ki-ouey (Ap. 2) elle était dans la constellation Che (α, β de Pégase). On le voyait le matin; sa longueur était 7°; elle alla fort vîte ver l'est . . . . le jour Sin-se (Ap. 24) on commença à la voir de soir; . . . . dans ce même temps on l'observa dans les Gemeaux . . . . La comète, en Chine cessa de paraître dans la constellation Tchang (entre le cœur de l'Hydre et la Coupe)."

The conditions in 1145 and 1066 were not unlike those predicted for the return of 1910. In each case the comet was discovered as a morning star, then lost in the Sun's rays; on its emergence it was near the Earth and moved with great rapidity, finally becoming stationary in the neighbourhood of Hydra, where it was lost to view.

Erratum,—M.N., vol. lxviii., No. 2, p. 123.

Revolution 1456 *to* 1531. Venus 330°–360° $\int dn$,

for $+''{\cdot}040$ *read* $-''{\cdot}009$. Sum of column to be altered accordingly.